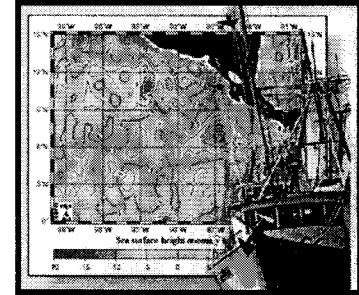


SATELLITE ALTIMETER APPLICATIONS

ALTIMETER DATA FOR OPERATIONAL USE IN THE MARINE ENVIRONMENT



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(Actually a cast of thousands!)

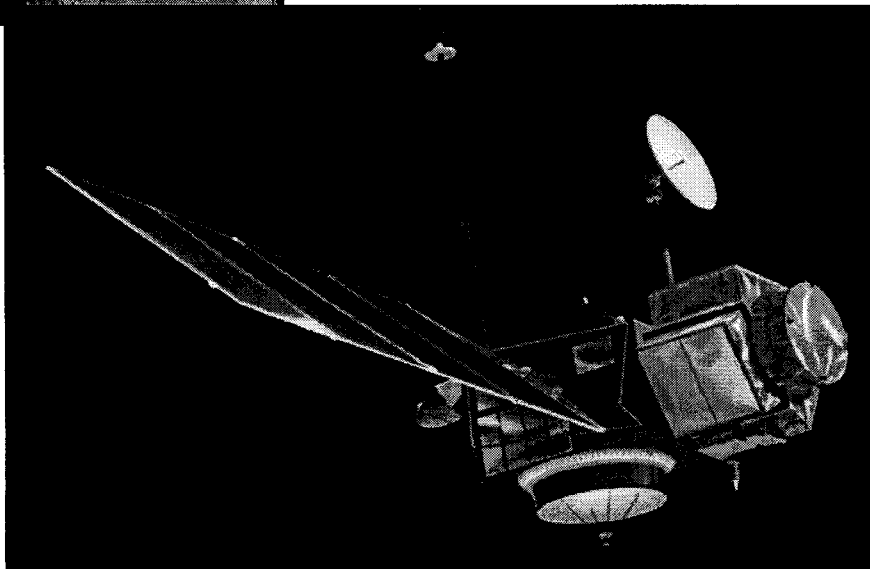
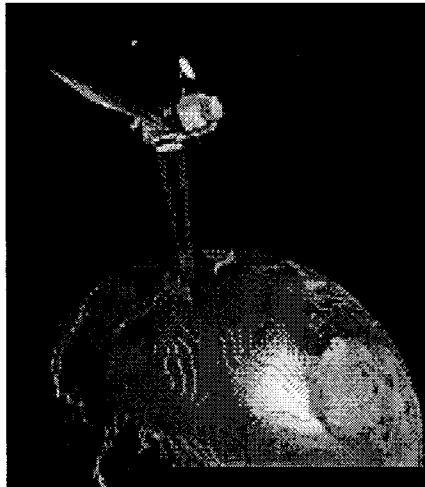
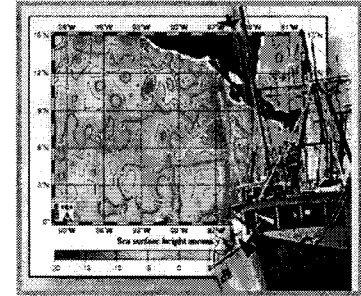
<http://topex-www.jpl.nasa.gov>

Digby, June '00

SATELLITE ALTIMETER APPLICATIONS

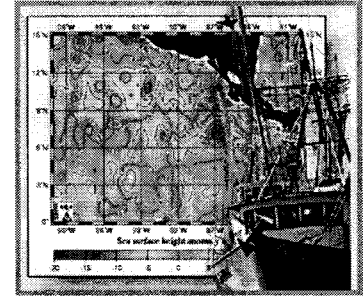
So what is an altimeter?

An altimeter is a type of radar. By measuring the length of time for the radar pulse to travel from the satellite to the sea and back, a map can be made of the sea surface topography. From TOPEX/Poseidon measurements, a global map is made every 10 days. The data are accurate to within 4 cm.



SATELLITE ALTIMETER APPLICATIONS

Information from altimeters

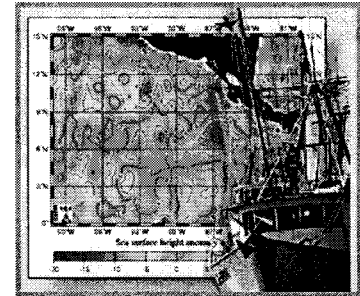


- **Sea Surface Height** - usually shown as sea surface anomalies
- **Geostrophic Velocity Vectors** - a large component of the current, information is often superimposed on maps of sea surface height
- **Wind Speed** - but not direction, (scatterometer data is usually used instead)
- **Significant Wave Height** - main usage is in climatologies
- **Derived products** - heat content, ocean acoustics, temperatures at depth

(available in digital form and as hard copy maps, and at a variety of timescales)

SATELLITE ALTIMETER APPLICATIONS

Altimeter Applications (operational and in development)



Marine operations

- **Ship routing** - sailboat races and commercial vessels
- **Ocean Acoustics** - detection of underwater objects
- **Underwater precision operations** - e.g. cable laying, ROV ops, hydrocarbon support

Marine Ecology

- **Commercial Fishing industry** - increases efficiency and safety
- **Cetacean Habitat** - marine mammal location associated with eddies
- **Debris tracking** - a growing hazard to corals and marine mammals
- **Fisheries Management** - better understanding of habitats, replenishment success

Weather and Climate

- **Hurricane forecasting** - seasonal prediction and individual storm behavior
- **El Niño/La Niña forecasting** - altimeter data assimilated into NOAA model
- **Pacific Decadal Oscillation** - detection and monitoring

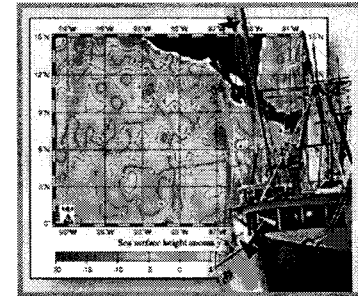
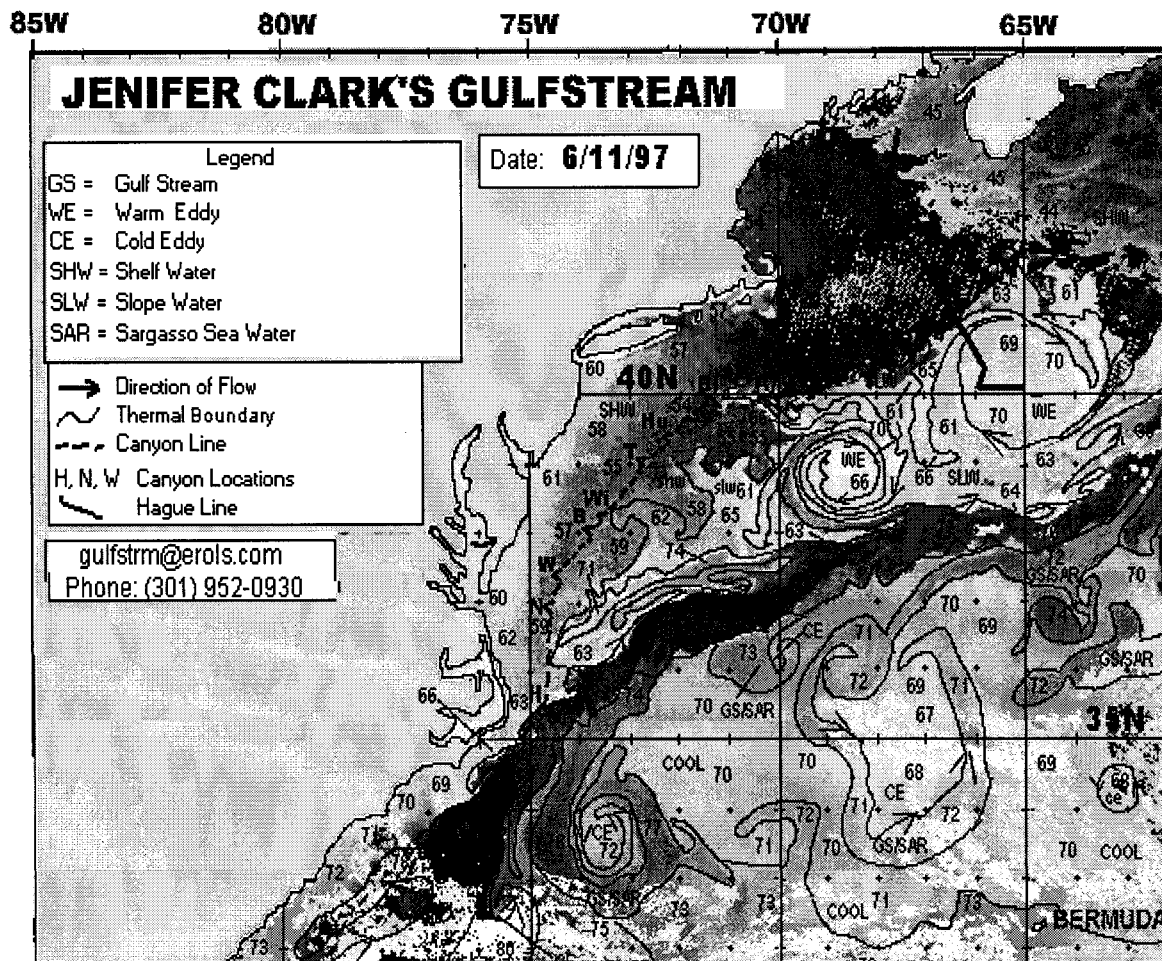
Other

- **Water budgets** - golf courses, parks
- **Energy futures** - companies that have a strong interest in future climate patterns

(Note: Often altimeter data are used in conjunction with other data)

SATELLITE ALTIMETER APPLICATIONS

Altimeter Products - ship routing

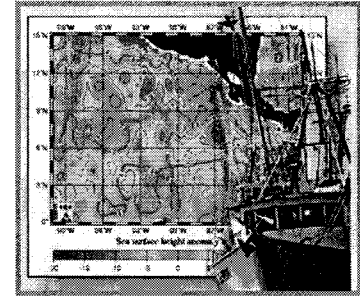


Service providers produce charts that incorporate altimeter sea surface height products from the University of Colorado and sea surface temperatures from NOAA. These charts are used by mariners involved in cable laying, transportation and hydrocarbon exploration.

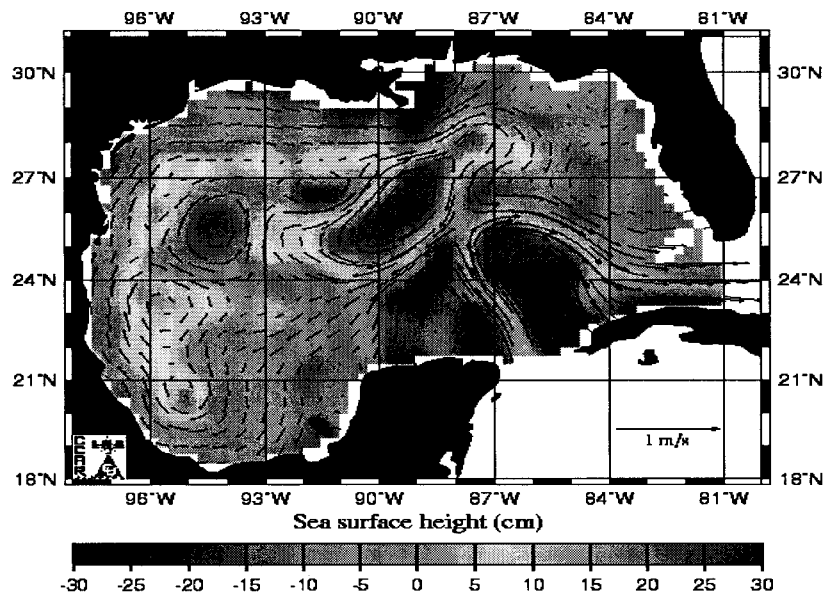
‘The last tug we routed was making several more knots due to optimum routing instead of rhumb line.’ (Feb 2000)

SATELLITE ALTIMETER APPLICATIONS

Offshore industries involving precision



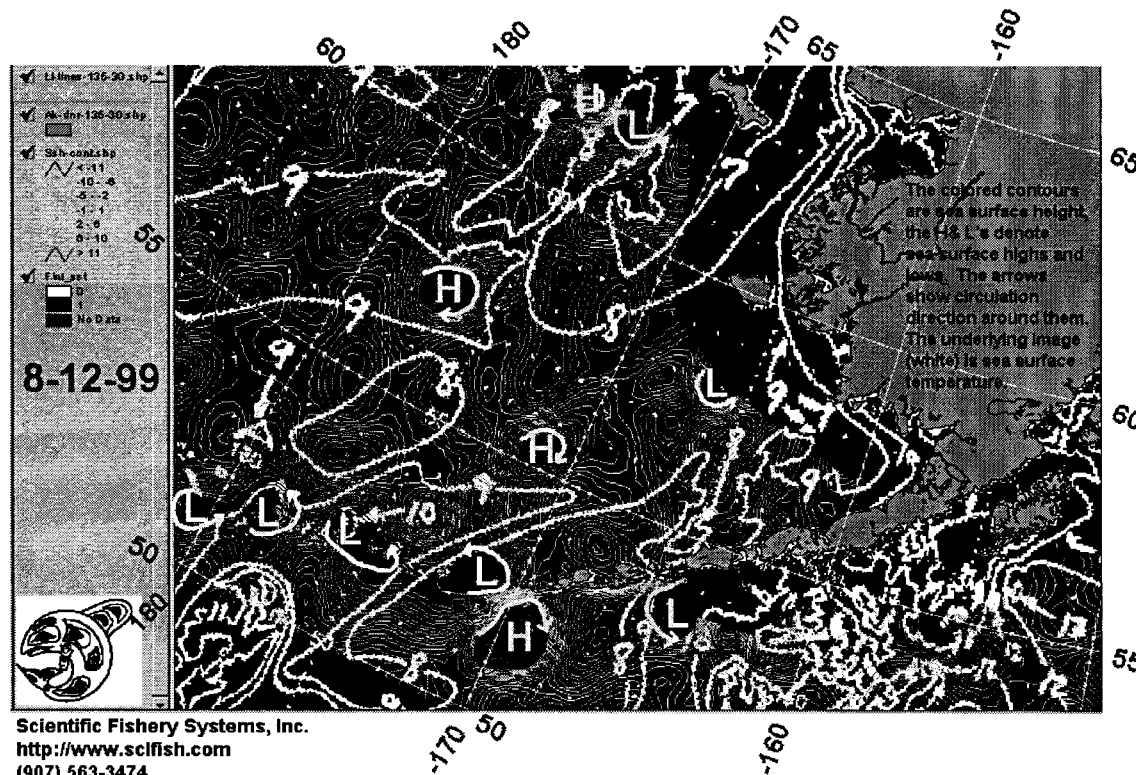
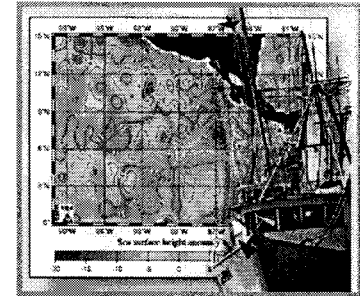
TOPEX/ERS-2 Analysis Aug 22 1999



- Cable laying ships, underwater ROVs and other offshore industries that have a need for precision, use maps of geostrophic velocities to avoid areas where there are strong currents.
- Eddies in the Gulf of Mexico can reach speeds of 4 knots.

SATELLITE ALTIMETER APPLICATIONS

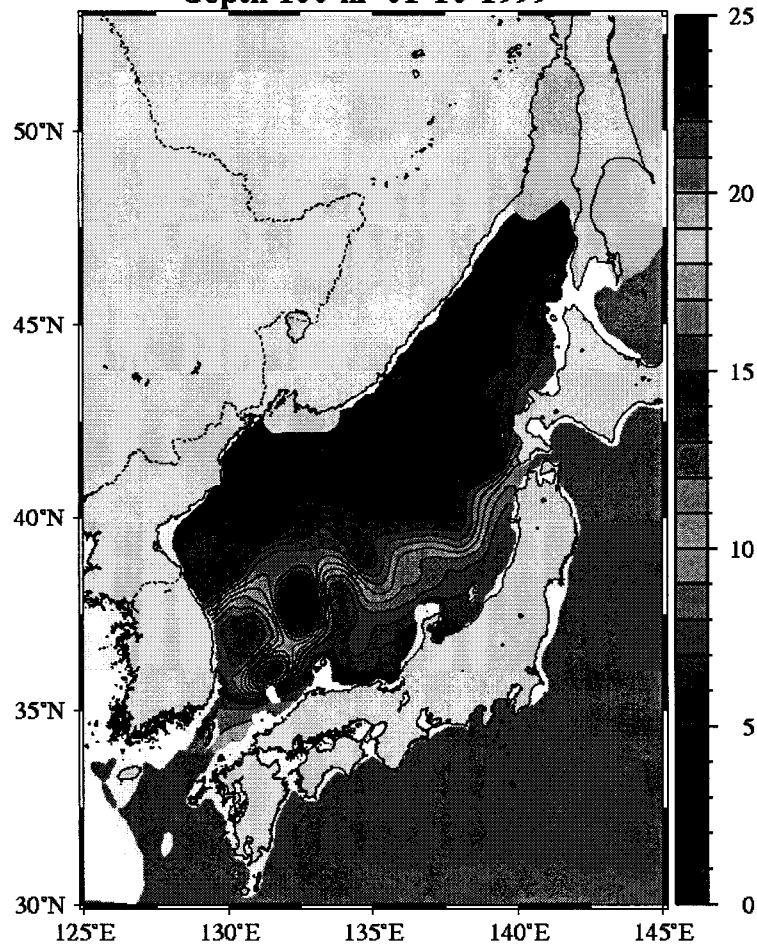
Altimeter Products - commercial fishery optimization



Colored contours show sea surface height data (source University of Colorado/ NASA), white contours and annotations are SSTs produced by NOAA.

Scientific Fisheries has pioneered a Geographic Information System (GIS) for offshore use that incorporates many types of fishing related and environmental information.

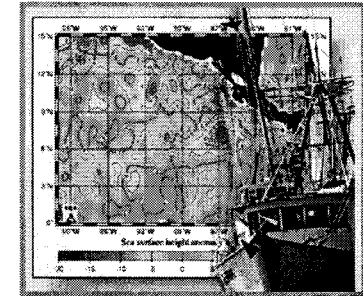
**MODAS synthetics: Temperature (C)
depth 100 m 01-10-1999**



Naval Research Laboratory MODAS 2.1

MODAS (Navy Modular Ocean Data Assimilation System) map of derived temperatures at a depth of 100m.

SATELLITE ALTIMETER APPLICATIONS



Map of temperatures at depth

Using statistical relations, historical in-situ data is linked to sea surface height and temperatures. Based on these derived relationships, contemporary SST and SSH measurements are used to reconstruct subsurface temperature and salinity.

Propagation of underwater sound is a function of temperature and salinity.

SATELLITE ALTIMETER APPLICATIONS

Ocean Acoustics

Acoustic signal excess, the estimated acoustic signal of an object relative to the background noise, can be better estimated with input from altimeter data. This information is used in submarine detection.

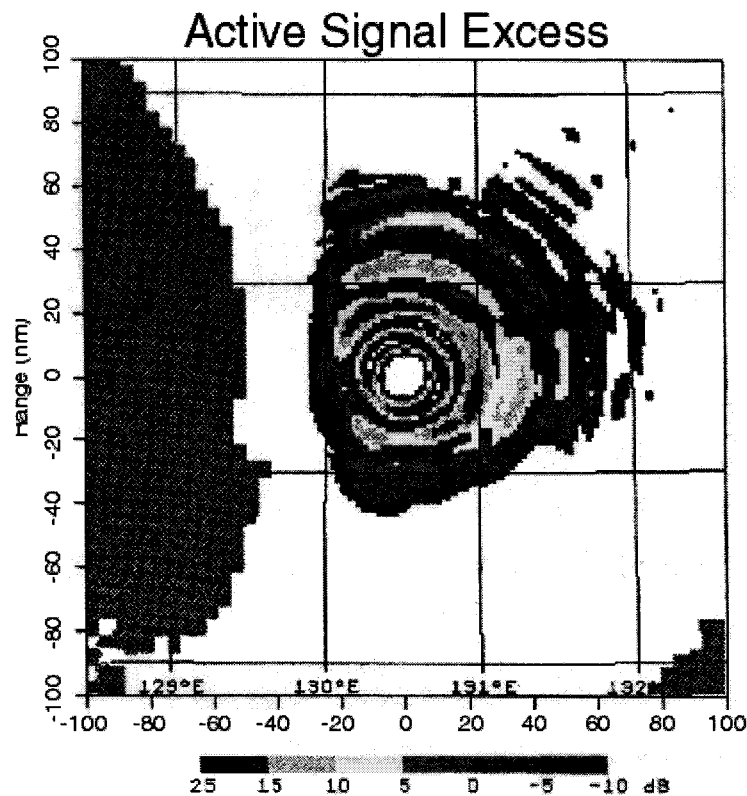
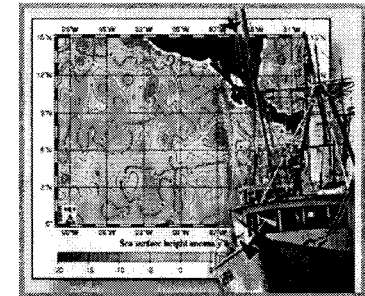


Chart derived from climatological data (note area is larger than actual conditions support)

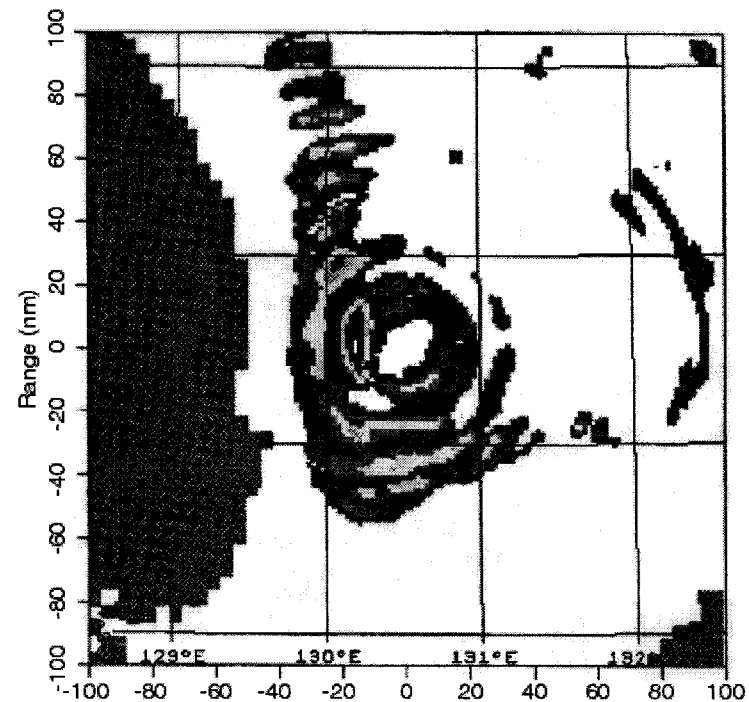
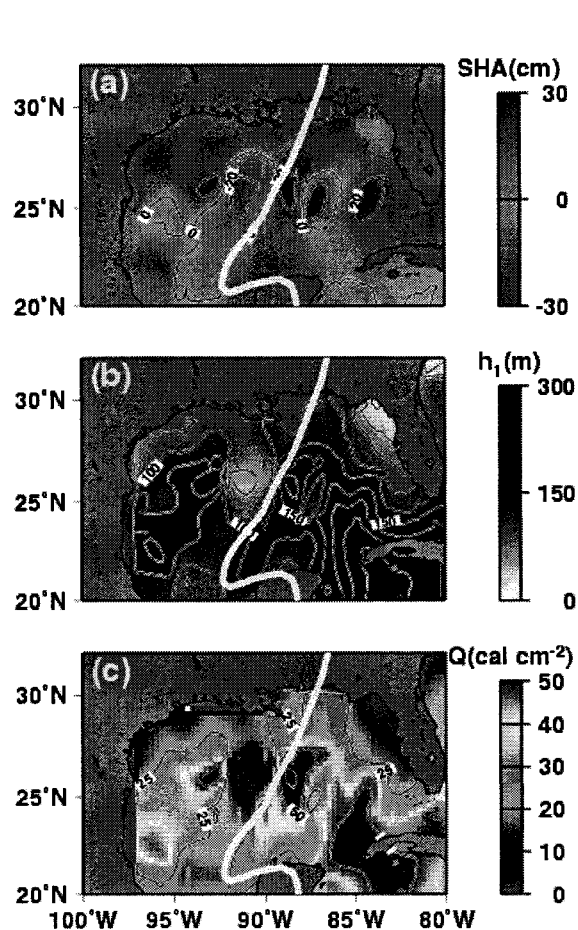
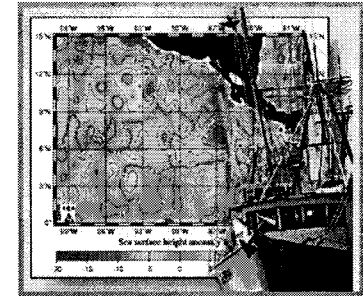


Chart derived from AXBT data - altimeter data may replace this intensive technique for gathering data

SATELLITE ALTIMETER APPLICATIONS

Hurricane Forecasting



Altimeter data is one of the tools, along with other remote sensing and in-situ data used to both:

- **predict the severity** of a hurricane season and
- **forecast intensity** changes of a given storm.

Hurricane Opal

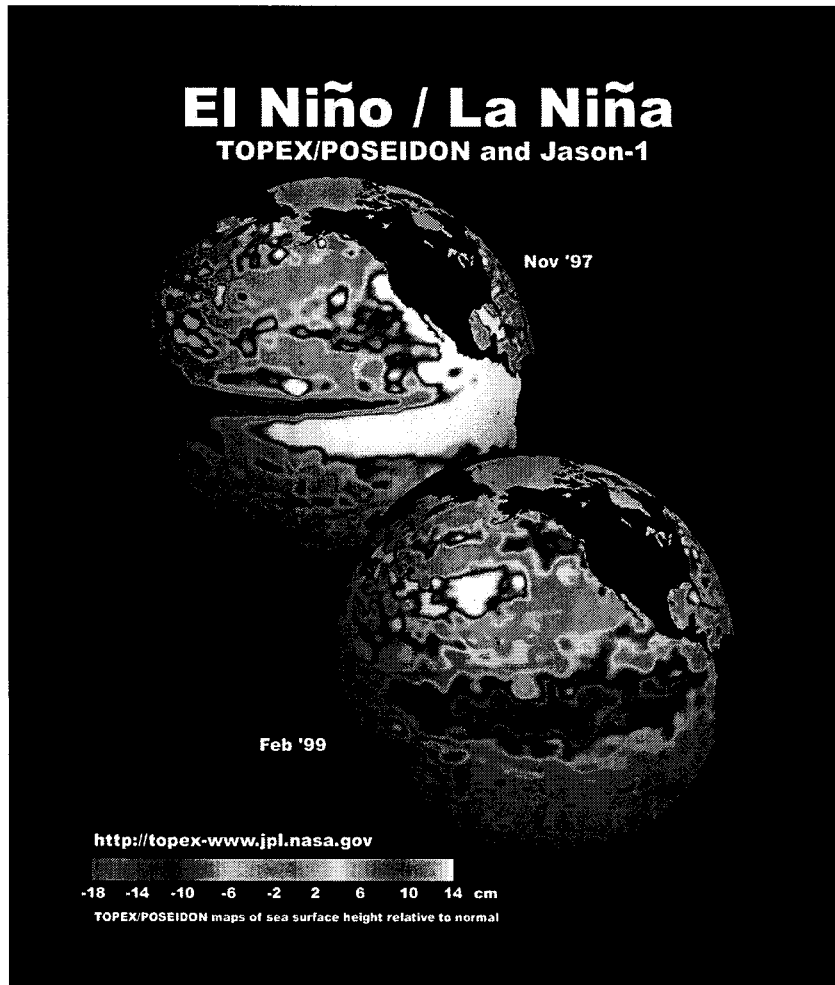
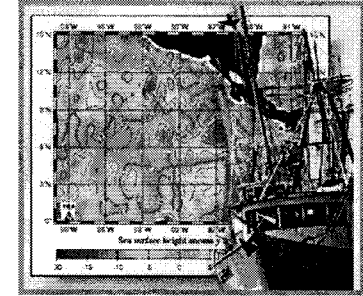
SHA - Sea surface Height Anomaly,
H - Depth of 26C isotherm,
Q - Integrated heat content

Hurricane Opal (yellow marks track) winds increased from 35 ms⁻¹ to 60 ms⁻¹ as she passed over a warm core ring.

S. Digby/June '00

SATELLITE ALTIMETER APPLICATIONS

El Niño/La Niña forecasting



The '97-'98 El Niño was seen in altimeter records approaching the American continents prior to it affecting the weather and climate. NOAA is using altimeter data, together with data for many other sources to produce seasonal forecasts.

Skilled seasonal forecasts enable people to take action such that loss of life is reduced and economic impacts are minimized.

SATELLITE ALTIMETER APPLICATIONS

TOPEX/Poseidon Altimeter

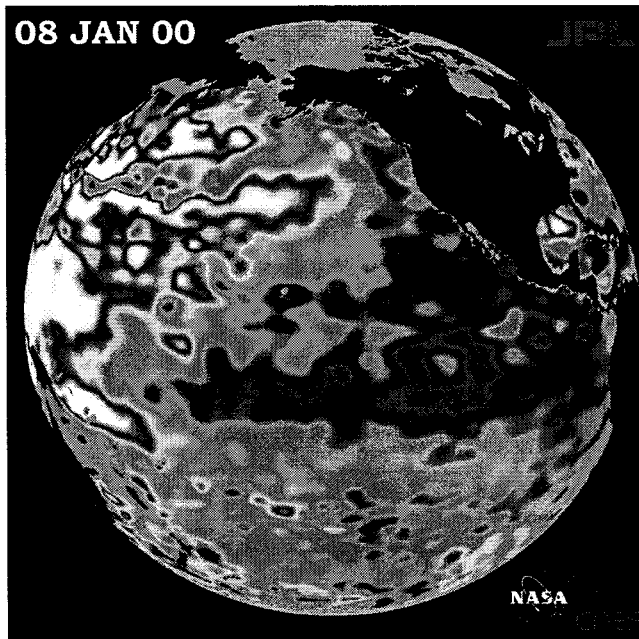
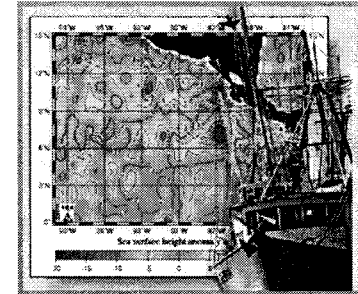
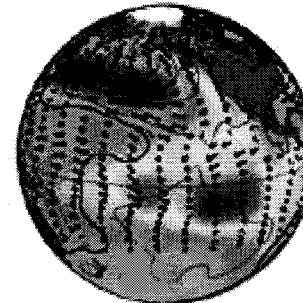


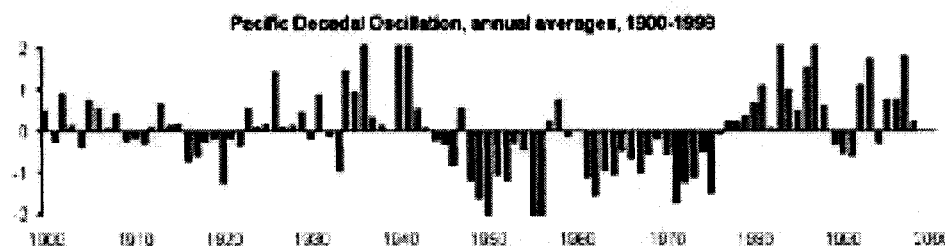
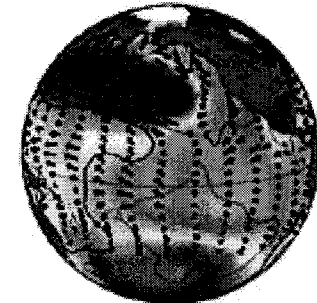
Image at left shows a horseshoe of higher than average (warm) water in the western Pacific Ocean (red and white), and lower than average (cool) blue and purple water in the eastern Pacific Ocean. This leads us to believe we entered the cool (negative) phase of the PDO in 1999.

Pacific Decadal Oscillation

positive phase



negative phase



PDO images above and left are courtesy of Nathan Mantua and Stephen Hare, University of Washington, Units are degrees Celsius

SATELLITE ALTIMETER APPLICATIONS

Marine mammal research

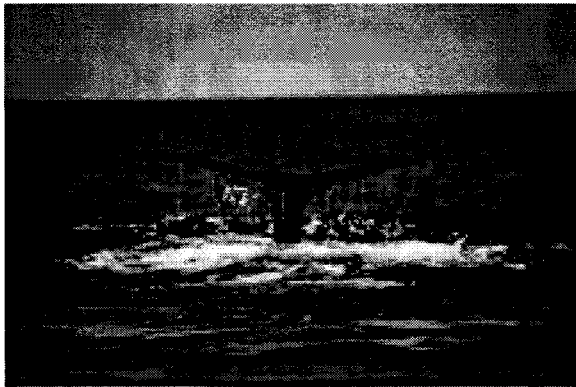
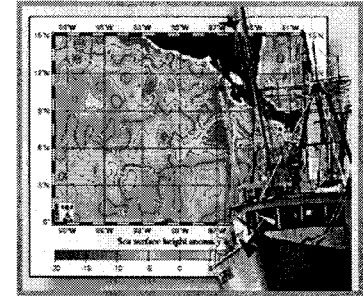
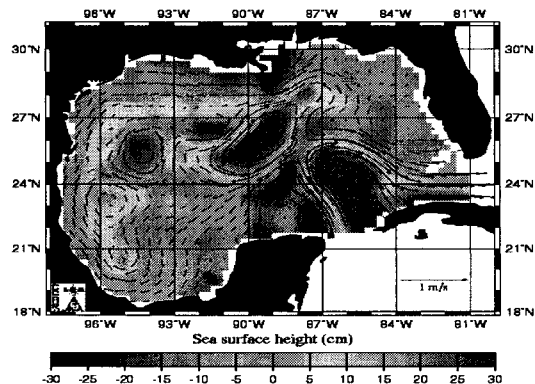


Photo: David W. Weller, NOAA

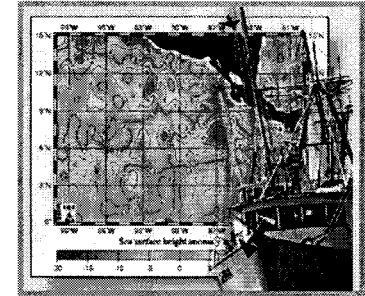
TOPEX/ERS-2 Analysis Aug 22 1999



- Altimeter data have been used as input to planning marine mammal surveys (GulfCet Program).
- Altimeter data have been used in analysis of marine mammal data.
- Whale pods were found near eddies where upwelling of nutrient rich water occurs. Eddies are seen on images as circular zones of low sea surface heights with counterclockwise circulation.

SATELLITE ALTIMETER APPLICATIONS

NOAA/National Marine Fisheries Service Southwest Fisheries Science Center

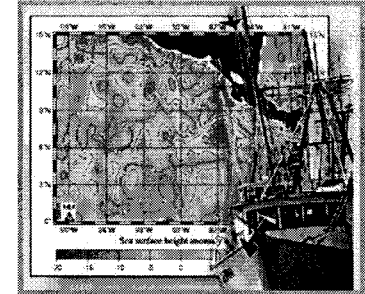


Altimeter data are being used (in concert with other data) to locate:

- **Marine debris** - Floating and partially submerged materials (natural and man made) can damage coral reefs, entangle marine life and cause damage to ships.
- **Identification of fish habitats** - for better understanding and management of resources.
- **Larval recruitment** - e.g spiny lobster - the larvae need to find a suitable habitat if they are to survive and become adult lobsters.

SATELLITE ALTIMETER APPLICATIONS

Accessing data and information



Applications pages and links to data sites:

<http://topex-www.jpl.nasa.gov/science/science.html>

Sources Of Images And Data:

- Jet Propulsion Laboratory (near real-time and precision data products, global)
- NOAA (near real-time images and data, global)
- Stennis (near real time images, regional, parameters also related to acoustics)
- University of Colorado (near real time blended ERS-2 and altimeter data, regional)

If you have questions please contact us! topex@jpl.nasa.gov